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(56) Documents cited

GB 1600257 GB 1452039

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GB 1578125 GB 1340983

GB 0813505

GB 1562086 GB 1181053

GB 1529354 GB 1176765

(58) Field of search

F2P

F2G

H5H

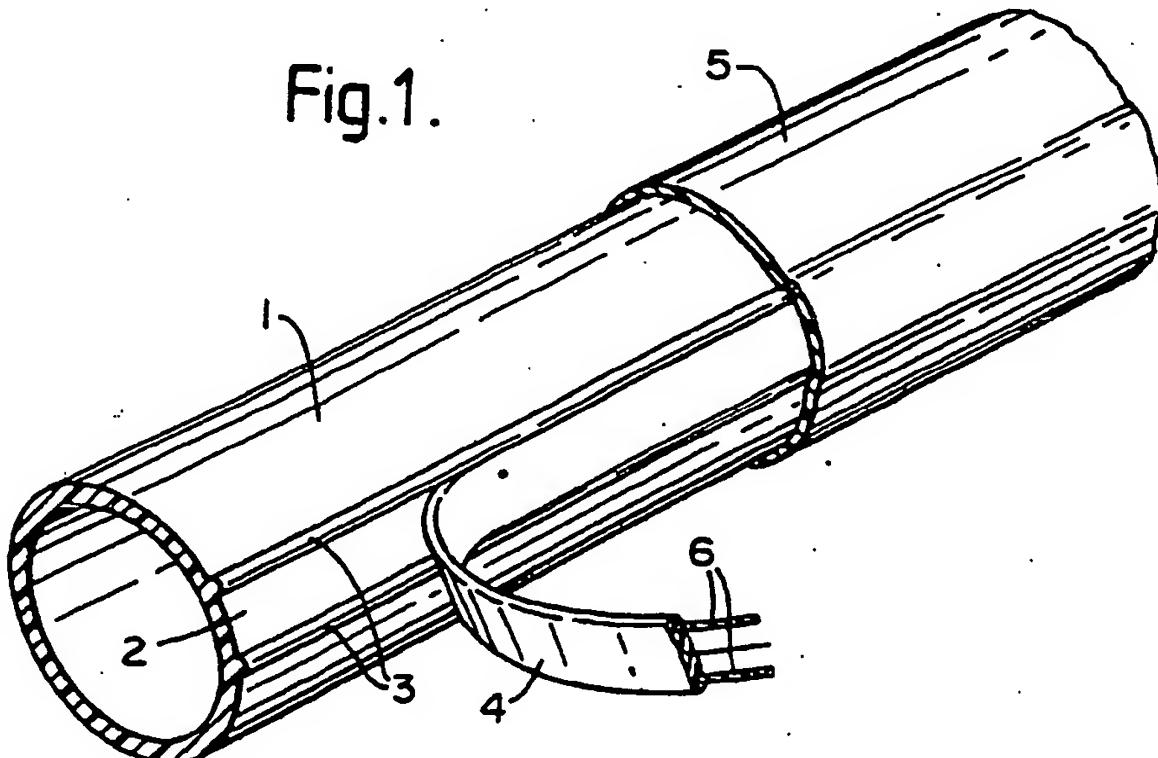
H2E

Selected US specifications from IPC sub-class F16L

## (54) Conduit with heater strip

(57) A polymeric conduit (1) has a heater strip (4) co-extruded in a wall thereof, thereby to enhance thermal transfer to the contents of the conduit. Straight or Tee-connector (Figs. 4-6) with electrical connecting bars (24) may be provided for connecting lengths of the conduit (1). The strip (4) exhibits positive temperature coefficient of resistivity (PTC) behaviour.

Fig.1.



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Fig.1.

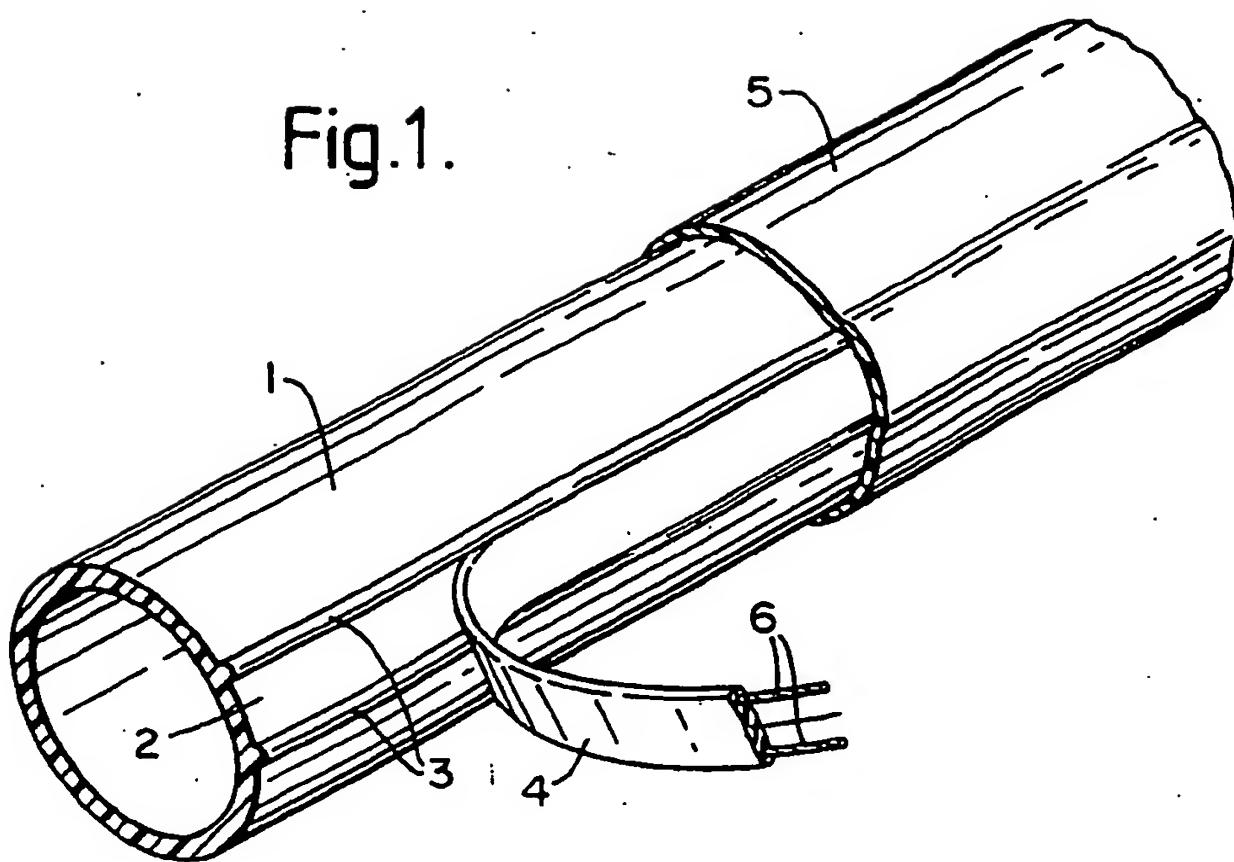


Fig.2.

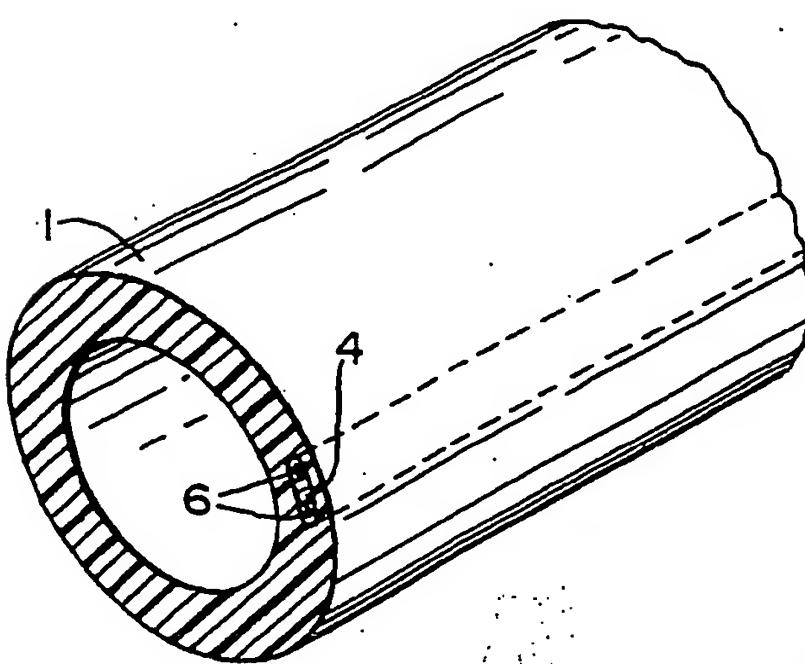
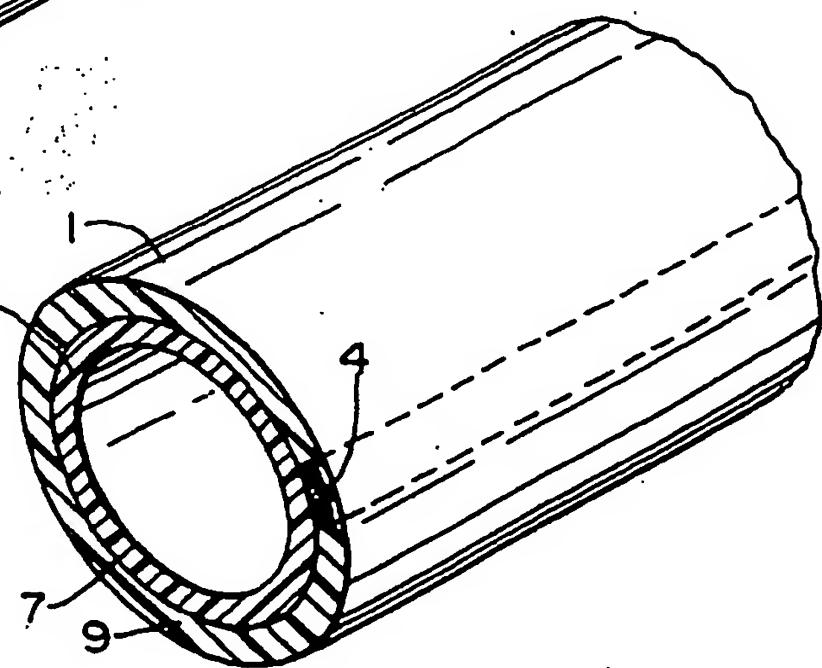


Fig.3.



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Fig.4.

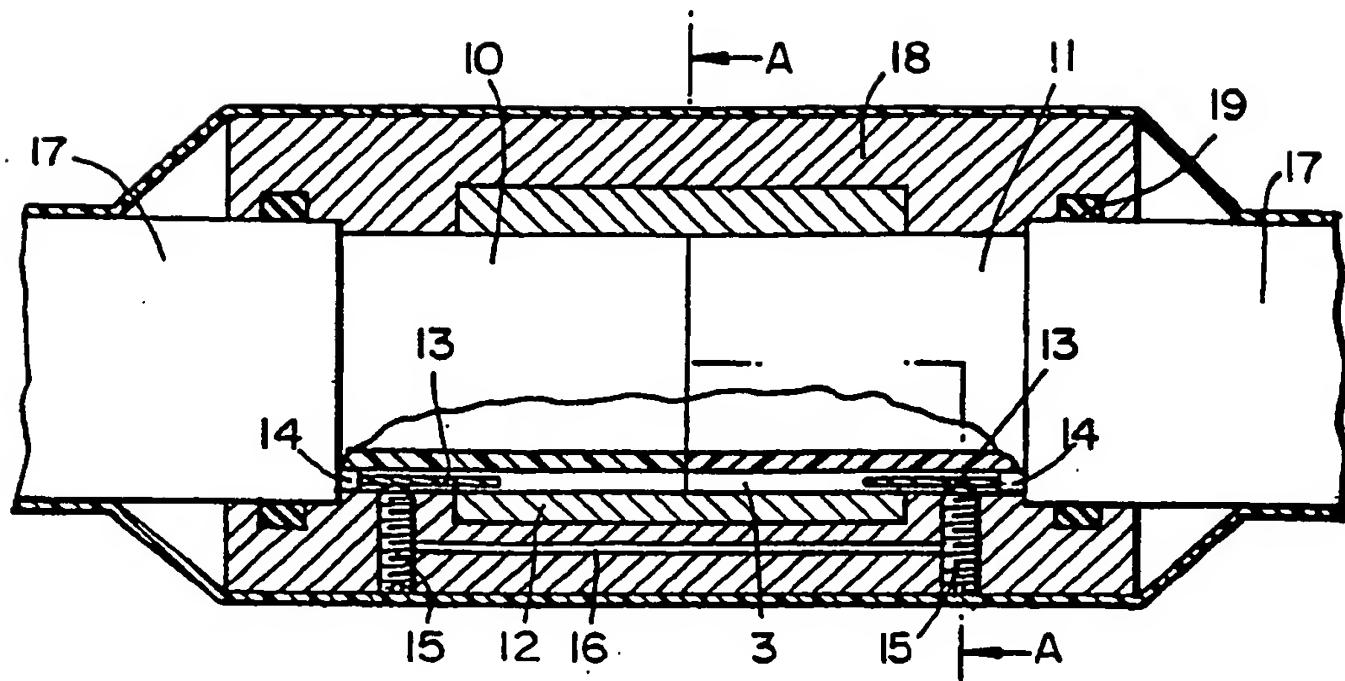
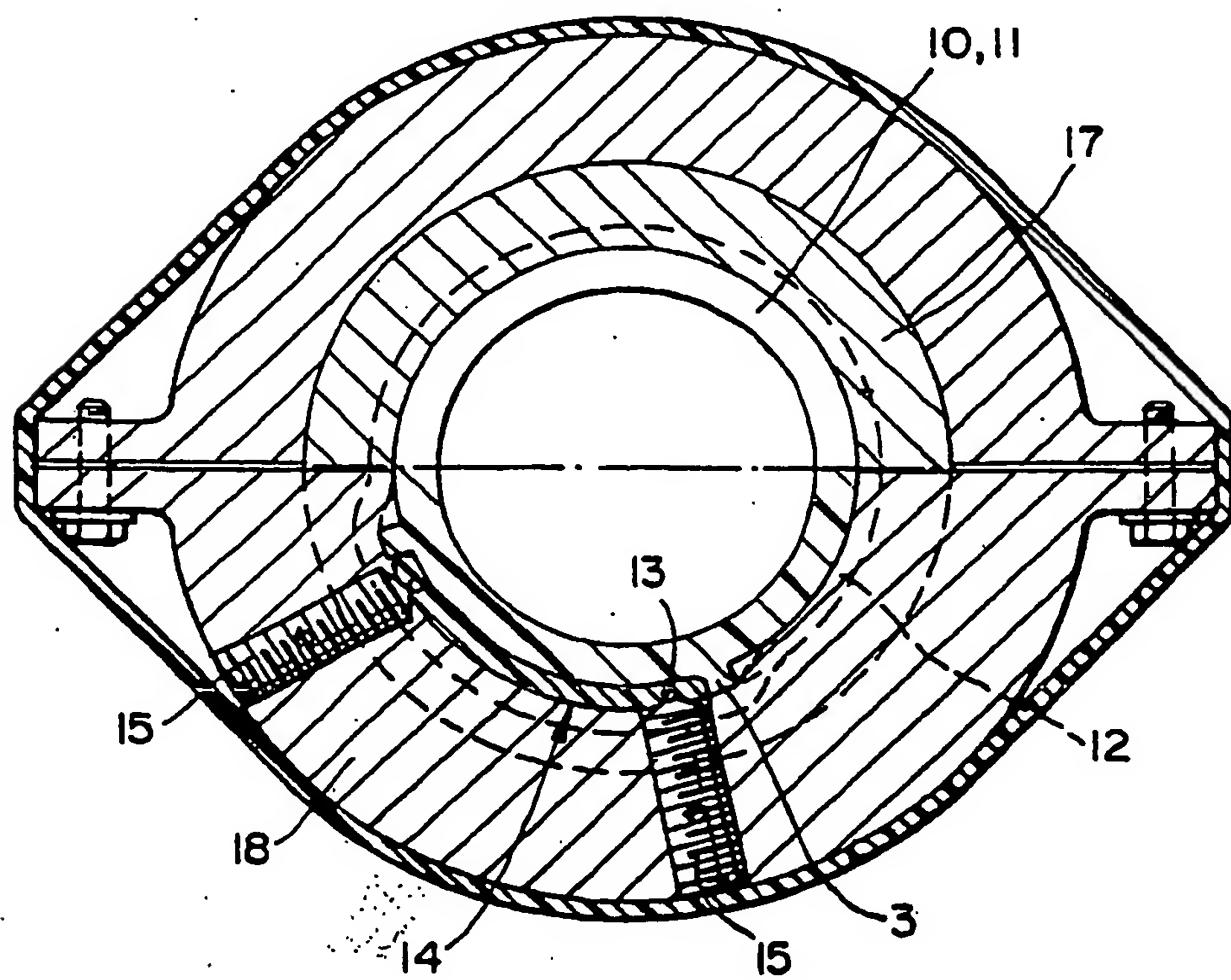
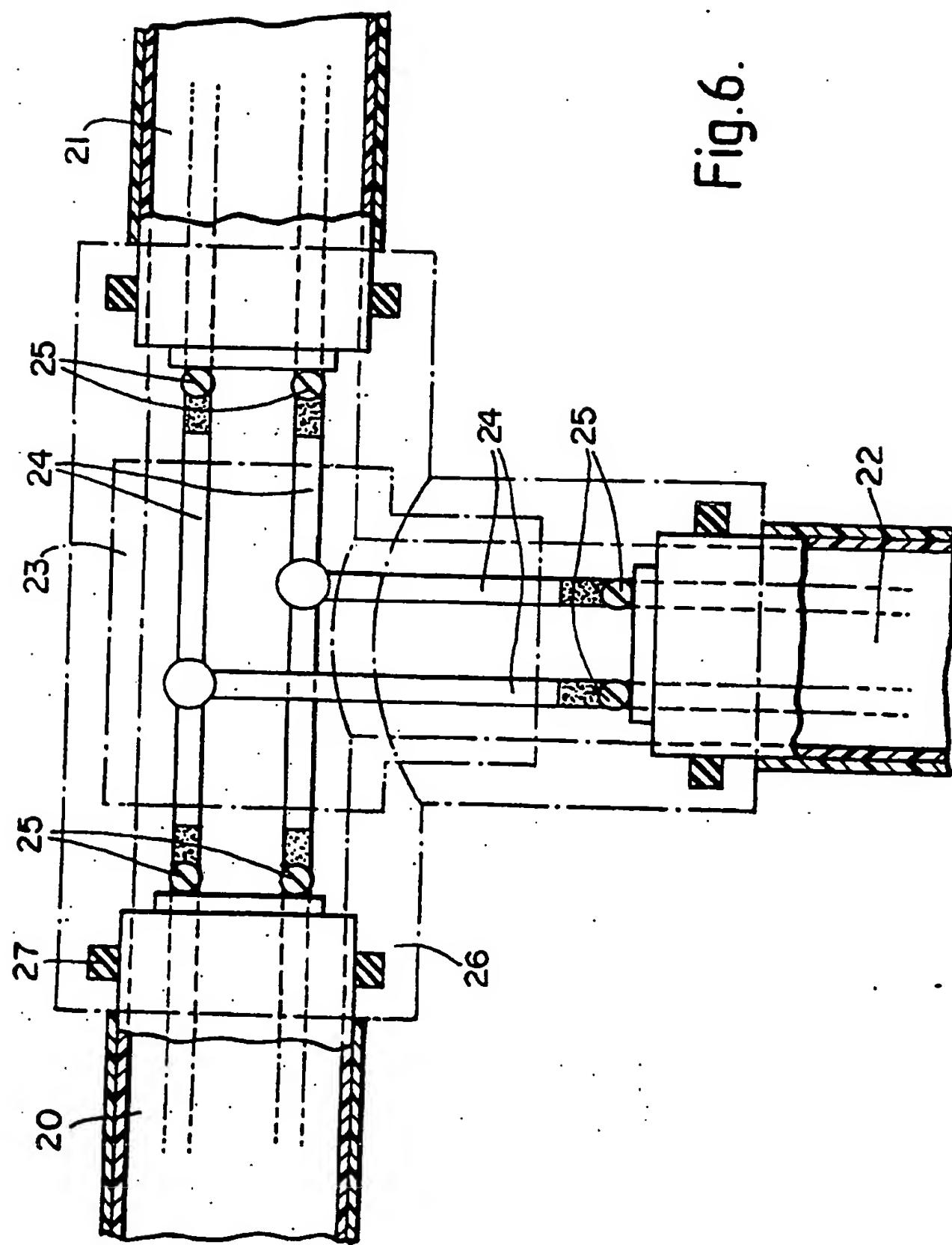


Fig.5.



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Fig. 6.



## SPECIFICATION

## Heated conduit

5 This invention relates to heated conduits, and more particularly to pipes provided with means for heating fluids passing therethrough. It has been proposed to provide pipes with electrical resistance heaters which are wound 10 around the outside of the pipe, with thermal insulation optionally being applied thereto in order to reduce heat loss. Such heaters are used not only for fluid heating but also for freeze protection. In recent years there has 15 been a change away from simple, constant wattage, resistance heaters, which are difficult to control effectively, towards self-limiting heaters, typically parallel circuit self-limiting heaters, for example of the type sold by Raychem Corporation under the trade name Chemalex. Such heaters are typically in the form 20 of a strip and comprise two parallel, rod shaped electrodes which extend along the length of the strip, and are embedded in a 25 conductive polymeric material.

The term "conductive polymer" is used herein to denote a composition which comprises a polymer component and, dispersed or otherwise distributed therein, a particulate 30 conductive filler. Documents describing conductive polymer compositions and devices comprising them include U.S. Patents Nos. 2,952,761, 2,978,665, 3,243,753, 3,351,882, 3,571,777, 3,591,526, 35 3,757,086, 3,793,716, 3,823,217, 3,858,144, 3,861,029, 3,950,604, 4,017,715, 4,072,848, 4,085,286, 4,117,312, 4,177,376, 4,177,446, 4,188,276, 4,237,441, 4,242,573, 40 4,246,468, 4,250,400, 4,252,692, 4,255,698, 4,271,350, 4,272,471, 4,304,987, 4,309,596, 4,309,597, 4,314,230, 4,314,231, 4,315,237, 4,317,027, 4,318,881, 4,327,351, 45 4,330,704, 4,334,351, 4,352,083, 4,361,799, 4,388,607, 4,398,084, 4,413,301, 4,425,397, 4,426,339, 4,426,633, 4,427,877, 4,435,639, 4,429,216, 4,442,139, 4,459,473, 50 4,481,498, 4,476,450, 4,502,929, 4,514,620, 4,517,449, 4,529,866, 4,534,889, 4,545,926, 4,547,659, 4,560,498, 4,562,313, 4,571,481, 4,574,188 and 4,582,983; commonly as- 55 signed U.S. Serial Nos. 141,989 (Evans), 250,491 (Jacobs et al) 300,709 and 423,589 (Van Konnenburg et al), 509,897 and 598,048 (Masia et al) 573,099 (Batliwalla et al) 596,761 and 720,117 (Rosenzweig), 60 629,645 and 732,527 (Afkhampour), 650,918 (Batliwalla et al), 650,919 (Batliwalla et al), 650,920, 663,014 and 735,408 (Batliwalla et al), 711,909 (Deep et al), 720,119 (Soni et al), 711,910 (Au et al), 818,845 (Rosenzweig) 65 846 (Barma). The disclosure of each

of the patents, publications and applications referred to above is incorporated herein by reference.

Self-limiting strip heaters represent a great 70 advance in the art but they can have some draw-backs when applied to pipes of plastics material, which generally have a very low thermal conductivity, for example less than 20w/Km, and are therefore very difficult to heat uniformly, and thus to maintain a required minimum temperature of the contents, using a strip heater. Attempts to solve this problem have involved providing the heater inside the wall of a pipeline, as shown in DOS 2707244, 75 or extruding a heater sleeve of polymeric material having conductive particles therein around the pipe as shown in US Patent 4429213. Each of these solutions requires complicated equipment and does not permit 80 the use of parallel-circuit self-limiting strip heaters, which are now the state of the art. We have now found that substantially uniform heating of pipes of low thermal conductivity, especially below 20w/Km, can be significantly improved, and in favourable circumstances achieved completely, by improving the thermal contact between the heater and the pipe, and by accommodating differences in thermal expansion of the heater and the pipe. 90 95 In one aspect, the present invention provides an elongate heated conduit formed from a polymeric material and an electrically conductive polymeric strip heater in intimate thermal contact therewith, the heater being provided with parallel electrodes capable of accommodating differences in thermal expansion of the heater and the conduit. In another aspect, there is provided a process for the production of an elongate heated 100 conduit, comprising extruding a polymeric conduit and an electrically conductive polymeric heater strip such that the heater strip is in intimate contact with a wall of the conduit, the heater being provided with parallel electrodes capable of accommodating differences in thermal expansion of the heater and the conduit. 105 110 In a further aspect, the invention provides an elongate heated conduit formed from a polymeric material, and an electrically conductive polymeric heater strip, the conduit being provided with means for improving the heat transfer between the conduit and the heater, and means for limiting the thermal expansion 115 120 of the conduit, so as to reduce differences in thermal expansion of the heater and the conduit. The conduit may be of open or closed cross-section, although usually it will be closed, for example a pipe or tube. 125 The invention is particularly applicable to the heat-tracing of polyethylene or polypropylene pipes, although it will be appreciated that it can be applied to any polymeric conduit 130 formed from any suitable polymeric material

including hydrocarbon polymers, fluorocarbon polymers, polyesters, polyamides, polyketones and similar materials. The invention is especially useful with polymeric conduits formed

5 from polymer materials having a thermal conductivity of less than 20w/Km, and most especially less than 10w/Km.

The polymeric conduits used in the present invention often have quite large coefficients of

10 thermal expansion, frequently greater than  $10 \times 10^{-6} \text{K}^{-1}$  and sometimes greater than  $50 \times 10^{-6} \text{K}^{-1}$  and this thermal expansion could put undesirable strains on the heater, for example if the heater is wound too tightly around the

15 conduit. Hitherto this has placed a limitation on the intimacy of the thermal contact which could be obtained between the heater and the conduit. This problem is solved in one aspect of the invention by providing the heater with

20 parallel electrodes which are capable of accommodating changes in length of the heater caused by expansion of the conduit. Such electrodes may comprise, for example, braided or woven conductive materials, or fabrics

25 either woven or non-woven, which can expand or contract in length to accommodate changes in length of the heater strip. Suitable electrodes are described and claimed in British Patent Specification No 1562086. Preferably the

30 electrodes are capable of expanding and contracting in length per degree Kelvin by an amount at least twice, and preferably at least four times the amount which the polymeric conduit expands or contracts per degree Kelvin, when heated or cooled. Preferably the electrode can expand and contract in length by at least 1%, and preferably at least 2%.

In a first embodiment of the invention, the conduit and the heater strip are co-extruded

40 so that the heater strip is inherently in intimate contact with the wall of the conduit. The heater strip may contact either the inside or outside of the conduit wall, or it may be wholly or partly embedded therein. For ease

45 of manufacture and convenience of later connection, it is preferred that the heater strip is in intimate contact with the outer surface of the conduit wall.

Alternatively, the heater strip may be first

50 extruded alone and then extruded in intimate contact with the conduit, for example in a cross-headed die. The latter process may be more convenient in practice, but will of course usually involve using as the conductive polymeric material of the heater one which has a melting point above that of the polymeric material of the conduit. For example, if the conduit is formed from polyethylene, the heater strip may be made from polyvinylidene fluoride.

55 In either process, the extrusion conditions can be varied to suit the polymeric materials involved. It will of course also be necessary to introduce the electrodes into the heater strip during the extrusion of the heater.

60 ~~Consequently~~ the "intimate contact" is such

that adjacent surfaces of the conduit wall and the heater strip are in contact over at least 60% of their area, and preferably at least 70%.

70 It is particularly preferred to use self-limiting heater strips in the heated conduits of the present invention, and such heaters usually comprise cross-linked conductive polymeric materials. The cross-linking process can be  
75 carried out by irradiation and this may be done in a separate operation or, and suitable cases preferably, may be carried out after the extrusion step. This has the advantage that the conduit polymer material may also be  
80 simultaneously cross-linked, thereby improving its physical and chemical properties.

As previously stated, the conduit may be provided with means for improving the heat transfer between the conduit and the heater  
85 strip. Such means preferably comprise a layer of material of good thermal conductivity which can extend around the conduit, preferably completely around, and which is in good thermal contact with the heater strip. Preferably  
90 the material is a metal foil, for example aluminium or copper foil, which should desirably have a thickness of at least 0.1mm preferably at least 0.2mm, more preferably at least 0.3mm. The thickness is typically from 0.1 to  
95 0.5mm, preferably 0.2 to 0.3mm. The foil may be on the inside or outer surface of the conduit wall, or may be embedded therein provided that it remains in thermal contact with the heater strip. In this embodiment the  
100 conduit is also provided with means for limiting its thermal expansion, and such means can, for example, comprise a reinforcing or stiffening means extending around or embedded in, the wall of the conduit. In a particularly preferred embodiment a metal foil provides the function of both improving the heat transfer and limiting the thermal expansion of the conduit. For example, a layer of conduit  
105 may first be extruded, then wrapped with metal foil, the heater strip placed on the foil, and a further layer of conduit extruded thereover, so that the foil and the heater strip are embedded in the pipe wall. Although this is a preferred construction, it should be emphasised that this is not the only possibility, and that, for example, two layers of metal foil could be provided, one for thermal transfer and the other for limiting thermal expansion of the conduit.  
110  
115  
120 In one embodiment in which means for improving the heat transfer with the heater strip, and means for limiting the thermal expansion of the pipe are provided, it is preferred to use self-limiting heater strips manufactured by Ray-chem Corporation and sold under the trade name HWAT.  
125 A particular advantage of the invention is that

130 A particular advantage of the heated conduit of the present invention is the convenience of installation. Many prior art heated conduits can be produced only in fixed lengths, which re-

quires a large inventory and its associated expense. The heated conduits of the invention by contrast can be cut to length in the field, thereby reducing wastage to a minimum.

5 Some embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 shows a perspective view of a 10 heated conduit with an extruded heater strip;

Figure 2 shows a perspective view of a second embodiment of a heated conduit with a co-extruded heater strip;

Figure 3 shows a perspective view of a 15 third embodiment of a heated conduit provided with a heater strip and a metal foil layer in contact therewith;

Figure 4 shows in sectional side elevation a 20 joint between two conduits, each according to the invention; and

Figure 5 shows a sectional elevation of the joint of Figure 4 along the line A-A; and

Figure 6 shows a sectional plan view of a 25 tee-junction between three conduits, each according to the invention.

Referring to Figure 1, the heated conduit comprises a polyethylene pipe 1 provided with a longitudinally extending groove 2 bounded by ridges 3 on its outer surface. A heater 30 strip 4 is positioned in the groove 2. The electrodes of the heater strip are formed from braided wires. The assembly is covered by an electrically and thermally insulating outer cover 5. The heater strip 4 is of the parallel circuit, 35 self-limiting variety and is provided with parallel electrodes 6.

The heated conduit is manufactured by extruding the pipe 1 whilst feeding into the extruder die the heater strip 4. The cover 5 is 40 extruded over the assembly in a subsequent operation.

The heated conduit of Figure 2 differs from that of Figure 1 in that the pipe 1 and the heater 4 are extruded simultaneously, the extruded die having a configuration such that the 45 heater strip 4 is embedded in the wall of the pipe 1. This assembly may then be irradiated using an electron beam which cross-links both the pipe 1 and the conductive polymer material of the heater strip 4. The parallel electrodes 6 of the heater strip 4 are formed from braided wires and have a 2% elongation and contraction in the longitudinal direction.

Figure 3 shows a further embodiment in 55 which the pipe 1 is provided with an aluminium foil layer 7 of thickness 0.2 mm which is embedded in the wall of the pipe and is in contact with the heater strip 4. This embodiment may be made by first extruding the inner 60 pipe wall 8, then wrapping around it the aluminium foil layer 7, applying the heater strip 4 and finally extruding thereover the outer pipe wall 9. The aluminium foil layer helps to conduct the heat around the pipe 1 and also limit thermal expansion and contrac-

tion movements of the pipe 1.

Figures 4 and 5 show a joint between two heated conduits wherein two plastic pipes 10,11 are joined by a connector 12, comprising a heat-shrinkable tube sold by Raychem Corporation under the trade name Ultrafuse. The connector 12 is shrunk into conformity with the pipe surface, and lies, on one side of the pipe, against the ridges 3 which project

75 on that side of the pipe. The insulation 17 on each side of the joint has been cut back to expose the pipes, 10,11 and the heater strips 14. The heater strips 14 have been partially cut back, so they do not extend to the abutting 80 ends of the pipes 10,11. The ends of electrodes 13 of the heater strips 14 are connected via a pair of grub screws 15 and a connection bar 16. The grub screws 15 are mounted in threaded holes in a casing 18 which, as can be seen from Figure 5, 85 comprises a pair of bolted half shells which mate around the joint. Grommets 19 form a seal between the casing 18 and the cut-back insulation 17.

90 Figure 6 shows the electrical connection system for a tee joint between heated conduits 20,21 and 22. The fluid carrying pipes are joined by a tee-connector 23 which is provided with electrical connecting bars 24. The 95 bars terminate in connecting screws 25 which electrically connect the heater electrodes to each other. An outer casing 26, sealed to the outer insulation of the pipes 20,21,22 by grommets 27, completes the assembly.

100

#### CLAIMS

1. An elongate heated conduit formed from a polymeric material, having an electrically conductive polymeric heater strip in intimate contact therewith, the heater being provided with parallel electrodes arranged to accommodate differences in thermal expansion between the heater strip and the conduit.

110

2. A conduit according to claim 1, wherein the elongate heater strip is in intimate contact with the outer surface of the conduit wall.

115

3. An elongate heated conduit formed from a polymeric material, and an electrically conductive polymeric heater strip, wherein the conduit is provided with means arranged to improve the heat transfer between the conduit and the heater strip and means arranged to limit the thermal expansion of the pipe, so as to reduce differences in thermal expansion between the heater strip and the conduit,

120

4. A conduit according to claim 3 wherein the means for improving the heat transfer between the conduit and the heater strip comprises a layer of thermally conductive material positioned around the conduit which is in thermal contact with the heated strip.

125

5. A conduit according to claim 4 wherein the layer of thermally conductive material comprises a metal foil.

130

6. A conduit according to any of claims 3

to 5, wherein the means for limiting the thermal expansion of the conduit comprises a reinforcing means extending around, or embedded in, the wall of the conduit.

5 7. A conduit according to claim 6 wherein the reinforcing means comprises a metal foil.

8. A conduit according to claim 5 or 7, wherein a metal foil provides both the thermally conductive layer and the reinforcing means.

10 9. A conduit according to any preceding claim, in which the polymeric material of the conduit has a thermal conductivity less than 20W/Km.

15 10. A conduit according to any preceding claim, wherein the polymeric conduit comprises a polyolefin, preferably polyethylene or polypropylene.

11. A conduit according to any preceding

20 claim, wherein the polymeric heater strip is provided with parallel electrodes which are capable of accommodating changes in length of the heater strip caused by expansion of the conduit.

25 12. A conduit according to any preceding claim, wherein the polymeric strip heater comprises parallel electrodes which comprise a fabric material, preferably a braided or woven fabric material.

30 13. A conduit according to any preceding claim wherein the conductive polymeric material of the heater strip has a higher melting point than the polymeric material of the conduit.

35 14. A conduit according to any preceding claim in which the heater strip is a self-limiting heater.

15. A conduit according to any preceding

40 claim in which the heater strip comprises a conductive polymeric material which exhibits PTC behaviour (positive temperature coefficient of resistivity).

16. A conduit according to any preceding

45 claim, wherein the heater strip extends longitudinally along the conduit at one circumferential location thereof.

17. An elongate heated conduit substantially as hereinbefore described with reference to the accompanying drawings.

50 18. A process for the production of an elongate heated conduit, comprising extruding a polymeric conduit and an electrically conductive polymeric heater strip such that the heater strip is in intimate contact with a wall of the

55 conduit, the heater being provided with parallel electrodes capable of accommodating differences in thermal expansion between the heater strip and the conduit.

19. A process according to claim 18,

60 wherein the conductive polymeric material of the heater strip is cross-linked.

20. A process according to claim 19, wherein the polymeric material of the conduit is cross-linked simultaneously with the cross-

65 of the material of the heater strip.

21. A process for the production of an elongate heated conduit as claimed in any of claims 1 to 17.

22. A process for the production of an elongate heater conduit substantially as hereinbefore described with reference to the accompanying drawings.

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